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## CORRELATION OF MENTAL AND PHYSICAL POWERS.

THE popular judgment as to the compatibility, or otherwise, of mental and physical superiority, tends, broadly speaking, towards one or other of two diametrically opposed conclusions. The old-fashioned view was that excellence in one of these directions almost certainly implied deficiency in the other. The successful hard-reading student was, it was taken for granted, a poor thing in respect of his body. His running was good for little, his jumping was worth nothing. He had chosen a career, which, whatever it might promise in the way of future or posthumous fame, was sure to give him, for his portion in this life, weak eye-sight, a narrow chest, and feeble muscles. Against this view, another and quite opposite one found considerable acceptance in many quarters. The "muscular Christian," as he came to be called, after Kingsley had represented him to us, combined a very superior mind in a very sound body. There was nothing new in such a view, and those who like broad generalisations may declare that it was the reassertion of the Greek way of looking at man, in opposition to the clerical or mediæval way. Anyhow, it was assumed that the large-limbed hero was sure to be found high up in university class lists; and that if any youth left college, after three years' residence, running and jumping no better than when he came, it was only too likely that his tutor would be found to be as dissatisfied with his career as his trainer could have been, had he been provided with one.

So long as we confine ourselves to advancing individual instances, or to proving our generalisations by portraying characters

in works of fiction, both of these views have plenty to say for themselves, and against each other. Quite recently, however, some statistics have been collected upon the subject, which, whatever their deficiencies, have at least the merit of attacking the problem in the only way in which anything resembling a solution can be hoped for. Some years ago Mr. F. Galton, to whose ingenuity and industry so many branches of statistics are much indebted, started an Anthropometric Laboratory at South Kensington, London, during one of the large exhibitions held there. In the course of the year many thousand sets of measurements were obtained ; but they had the drawback, which every statistician will recognise, that they were drawn from rather heterogeneous data. Men and women were alike dealt with, and these differed widely in age, social position, and previous bodily development ; whilst the application of any mental test was quite out of the question. Another laboratory, therefore, of the same kind was started at Cambridge, where, as we shall soon see, most of these drawbacks were either absent or much reduced in importance.

As regards the physical tests, little need be said here, as they are mostly of a familiar kind. They dealt with the seven following particulars: (1) Eye-sight, i. e., the distance at which small "diamond type" print could be read with each eye separately. (2) Strength of pull, as in the action of drawing a bow ; this was measured in pounds. (3) Strength of squeeze, with each hand separately. The instrument here had two handles at a few inches' distance apart, which were squeezed together against the action of a spring. The pressure exerted was measured in pounds. (4) The height (without shoes) measured in feet and inches. (5) The breathing capacity, measured by a spirometer. The number of cubic inches which could be exhaled, after taking a deep breath, was thus recorded. (6) The weight, in pounds, taken in ordinary in-door costume. (7) To this was added the measurement of the head in three directions at right angles to each other. The product of these three elements gave, on the average, a number proportional to the volume of the head. For brevity, this product has been here termed the "head volume."

As regards these physical tests, little explanation is needed, as they are familiar to most students of statistics, and some of them have been applied on a vastly more extensive scale than anything now to be described. The only points that need present notice is the *homogeneous* character of our data. The students at the English universities are mainly drawn,—as they have been since the time of the Reformation at any rate,—from what are commonly called the upper classes. That is, nine out of ten of them are the sons of country gentry, professional men, and well-to-do tradesmen. Physically speaking, they have generally been made the most of; since they, and their fathers before them, have been duly fed and clothed and exercised. There is, consequently, none of the irregularity of result which may be observed sometimes in statistics dealing with army recruits, when immature youths are suddenly put, for the first time in their lives, into a position really favorable to physical growth. As regards the homogeneous character of the human materials here dealt with, every statistician will realise its importance. A comparatively small number of accurate observations, applied to a well-defined class, will often outweigh in value a vastly greater number which have been drawn from a medley of various classes.

So much for the merely physical tests. Such novelty, however, as there is in our present results lies mainly in the attempt to bring some kind of mental test into correlation with the physical. I need hardly insist upon the difficulty of such a task. Many people think they understand as clearly what they mean by an “able” man, as by a strong or a tall man. Perhaps they do; but they soon find that every one else understands it just as clearly as they do themselves, and with a totally different result. The first-class orator, preacher, or poet in one judgment is plucked without question in another. In an elaborate indictment of the *Cambridge Mathematical Tripos*, made some years ago, the critic asserted, amongst other objections, “that the best man invariably came out second.” This was not quite true; but if it had been, did it cross the writer’s mind what sort of an upheaval of the foundations of society would result

from a determined attempt to hoist the best man in each department of life as near the top as that?

In a much examined university,—and perhaps nowhere else,—it does become possible to arrange and classify men with regard to their mental powers. There is, of course, no question here of taking an arithmetic mean, and it was not even attempted to arrange the men in order of merit. All that was done was to group them into three classes, respectively denoted here as *A*, *B*, and *C*. In *A* are included all those who attain a first class in any honor examination, or who secure a college scholarship. *B* comprises all the rest of the men who pass in honors, that is, the second and third-class men in their various examinations. *C* comprises all who merely pass for their degree, or try to do so and fail. What with the multitude and varied scope of modern examinations, and the intimate knowledge of the capacities and attainments of their pupils possessed by most of the tutors, there was no great difficulty found in grouping the students in this way. I am well aware of the objections which may be raised. It is not for a moment claimed that such a classification is perfect, even within the modest limits at which it aims. Able men may fail in the class lists through indolence or ill-health, as inferior ones may succeed through luck or drudgery. But it must be remembered that we only profess to deal with averages, not with individuals, and on averages such influences have little power of disturbance. There are probably few cricket or foot-ball clubs in which one or more men in the second eleven or fifteen may not be really better than some in the first; but what chance would the second team have of beating the first? If we were selecting an individual as a tutor or secretary, it would be folly to prefer an *A* to a *B*, without further inquiry; but to weigh groups against each other is a very different matter. All that is here maintained is that our *A*, *B*, *C* classes, *as classes*, stand out indisputably distanced from each other in respect of their intellectual capacity. Not only is the average superiority of one group over the next patent to all who know the men, but we may safely say of them, what could perhaps be said nowhere else, that if the men had to vote themselves into three such

classes, the results would not be very different from what were obtained by the tests actually employed.

Before proceeding to our main subject of comparison, there is one remark which I should like to make in reference to the physical tests. These were made in six specified particulars, the choice of these particulars being partly decided by the facility of prompt and accurate determination. It may fairly be inquired whether these are isolated characteristics, in the sense that preëminence in one of them carries no superiority in the others. If this were so, their significance would be much diminished, for the testimony of one of them would not corroborate that of the others. The tall men might tend to be stringy, the heavy ones to be puffy, and the man with great capacity for expiration might, so to say, have sacrificed the muscles of his sword-arm in order to devote himself to the peculiar duties of a trumpeter. The exact extent to which decisive superiority in one physical characteristic is thus associated with comparative superiority, or otherwise, in respect of other characteristics, has not, as far as I know, been previously investigated, and it is therefore worth while to give some statistics on the subject. The general conclusion we find to be that the man who is very good in any one direction physically, is distinctly above the average in all the other directions. The most striking proof of this fact is arrived at as follows: Conceive a selection made of "the best in ten." If there are a thousand, select the hundred best; if, as in the Cambridge statistics, there are about three thousand, select the three hundred best. This is, of course, to make a high demand. It was found, for instance, that this bodily "first-class man" was, in respect of height, six feet or upwards; in respect of breathing he could expire three hundred and five cubic inches; his minimum pulling strength was one hundred pounds; his "squeeze," with his strongest hand, was also about one hundred pounds. The test for his eye-sight required that, with each eye separately, he could read the small print employed at a distance of at least thirty-four inches. The following table gives a summary view of the results of comparing the various classes; each of these being selected, of course, for eminence in one quality only.

FIRST CLASS.	EYES.	PULL.	SQUEEZE.	BREATHING.	HEIGHT.	WEIGHT.
Eyes.....	34.7	87.5	84.3	265.3	69.41	157.1
Pull.....	25.6	112.3	94.1	282.9	69.98	167.7
Squeeze.....	24.5	95.7	102.3	279.8	70.41	169.2
Breathing.....	24.8	93.8	91.4	321.0	71.34	168.1
Height.....	24.6	88.3	89.2	291.0	73.31	170.8
Average student ..	23.6	83.0	83.4	255.4	68.91	153.3

The meaning of this will be readily understood. Thus the men comprising our first class in respect of their pulling power (the minimum requirement being one hundred pounds) can, on an average, read at a distance of 25.6 inches; can, on an average, pull 112.3 pounds, and so on. The result is, I think, rather remarkable, for it is seen that great superiority in any one direction implies decided superiority in every other direction. That some of these capacities should be thus correlated is only what we should expect; it would be thought strange, for instance, if pulling and squeezing power did not go together, or height and weight. But one could not with equal confidence have anticipated that the taller men should have distinctly better eye-sight; or that the men selected solely for their superior eye-sight should have decidedly better muscles for pulling purposes, and stand half an inch taller than the average. The reader must not underrate the significance of the apparently small differences with which we are concerned. We are dealing with the averages of large numbers; large enough to make a difference of half an inch of stature utterly unaccountable as a mere coincidence.

This extent of correlation of physical powers seems to me to add considerably to the value of our tests. It meets the objection that we have no right to assume that the tall man, or the man with muscular arms, is in the widest sense of the term a physically robust or strong man. If we find that four or five perfectly independent tests all point in the same general direction, we have some ground for supposing that the qualities thus tested are *not* independent, but that they are integral components in the building up of the generally healthy and powerful man.

As regards the comparison of the intellectual and the physical arrangements of our men, the simplest plan is to give at once a summary table of the results.

	NUMBER TESTED.	EYES.	PULL.	SQUEEZE.	HEAD.	BREATH- ING.	HEIGHT.	WEIGHT.
<i>A</i> ....	674	22.9	81.8	83.4	243.82	256.5	68.81	153.0
<i>B</i> ....	1370	23.7	82.8	83.2	238.34	255.7	68.98	152.5
<i>C</i> ....	1138	23.9	84.1	83.6	236.44	254.5	68.88	154.2

Such a table as this may be examined with two different degrees of minuteness in respect of the appreciation of differences ; which would commonly be called the practical and the theoretical way of regarding them. By the former, speaking in the more accurate language of statistics, we may understand a degree of precision which does not recognise distinctions of less than about four or five per cent. of the totals involved. Looked at with this degree of nicety, the main fact that the tables yield is that there is really no difference between the physical characteristics of the different intellectual grades. Whether in respect of height, weight, power of squeeze, eye-sight, breathing capacity, or head-dimensions, one class is just about as good as another. The trifling existent differences tell sometimes one way and sometimes the other, and appear, to the eye of the plain man, well within the scope of accident. There are, indeed, three points about which some doubt might be felt, viz., the size of the head, the pulling power, and the eye-sight. The first of these is of sufficient importance to be reserved for special examination, and will be subjected presently to a severer test. The two latter are just the sort of differences as to the significance of which the untrained mind is troubled with a doubt. The high-honor men show a trifling inferiority of eye-sight, it is true ; but the diminution does not, so to say, step on uniformly through the three classes, *A*, *B*, *C*. On the other hand, the falling off in strength of pull, though no larger in amount, does seem to keep step somewhat better.

The matter is worth looking at a little closer from a slightly different point of view. Revert to the physical distribution of the men, described already, in accordance with which they were grouped into ten classes ; and select the top class, which comprises "the best in ten." They are, in each separate department, about three hundred in number. We may then inquire, in respect of these exceptionally



vigorous men, How are they distributed as regards *A*, *B*, *C*? We know in what proportions they ought to be distributed, by mere chance, or if their bodies and their minds had, so to say, nothing to do with each other : are the proportions actually found to prevail, very different from this? The answer is that, as regards eye-sight, any doubt which we felt at first may now be considered as much weakened, if not set aside. The most perfect powers of vision which our test can furnish are very nearly as likely to be found amongst the hard-reading and high-honor men as amongst the idlest. The total number of this first class in respect of sight was 302. The distribution of them into *A*, *B*, and *C* that would have been expected if the qualities were quite independent is 64, 130, and 108 : the actual distribution is 61, 140, and 100, a very trifling difference. It is quite clear that, taken as a whole, our studious men do not overstrain their eyes. As regards the pulling power, the decision yielded by this method tells the other way ; and suggests that, for one reason or another, hard reading and hard pulling are slightly, though only very slightly, incompatible. The figures are these. Our first class here contains 289 men. If these had been drawn at random out of the *A*, *B*, *C* classes, we should have expected these three classes to furnish respectively 61, 124, and 104. As a matter of fact they furnish, 41, 119, and 129. Such a difference as this, then, indicated by one kind of evidence and confirmed by a slightly different kind, cannot be regarded as accidental. Why is it that the hard-reading men, who are just as well developed in general respects,—who stand as high, weigh as heavy, and have equally clear eyes and sound lungs, and can even squeeze as hard with the muscles of the hands,—why is it that they show a small but distinctly marked deficiency in the particular action of pulling at a bow? The only reason which seems at all plausible is that though these men take abundantly sufficient out-door exercise to develop their *general* capacities, they, or a considerable minority of them, do not so largely practice certain athletic exercises which strengthen the muscles in question. In other words, they are presumably less addicted on the whole to rowing, cricket, and tennis. One would not have thought it was so, speaking from a general knowledge of their habits ; but

it certainly seems as if this was the only probable explanation of the undoubted facts of experience.

The foregoing conclusions are, I think, the most important which could safely be drawn by the practical man who judges the statistics as they stand ; that is, without resort to any of the tests which theory can offer for our help. When we resort to this aid we are able to give a satisfactory answer to the question whether the reading men, as a rule, have bigger heads. On the face of the matter it is clear that they do, so far as these statistics extend. Moreover there is a successive advance of size from *C* to *B*, and from *B* to *A* ; and also, what does not appear from the only tables we can find space for here, the same progressive advance is exhibited in each of the three separate batches of about one thousand each, of which the total before us is made up. Still the resultant difference is numerically small : it only amounts to somewhat less than three per cent. of the totals. Can any reliance be placed upon such a small difference?

The answer is that the difference *is* significant, past all bounds of reasonable coincidence or accident. The way in which the statistician treats the question is well recognised. He first inquires what is the amount of fluctuation or variation amongst the detailed measurements ; this gives him a measure of the degree of uncertainty attaching to the individual observation. He then asks what is the total number thrown together into one class in order to furnish an average. A great deal turns upon the magnitude of the numbers with which we are thus dealing. If, for instance, we had based our conclusion upon the averages drawn from classes consisting of only *ten* each, nothing worth a moment's notice would have been obtained. If based upon a hundred, the conclusion would still have been worth but very little. But in the case before us we have, roughly speaking, about a thousand separate instances in each of the three classes under comparison. It admits of proof that a difference amounting to three per cent. has chances measured by thousands to one against its having been of accidental origin. We need feel no manner of doubt that if we were to take a fresh batch of three thousand measurements of the same kind, and subject them to the

same sort of examination we should have a recurrence of the same results. This is, in fact, what we mean by a non-accidental phenomenon.\*

The set of statistics from which the above conclusion was drawn were also employed to decide another, and very different question. It has, unless I am mistaken, been held that the growth of the head ceases at about 19. Our statistics, when the *A*, *B*, *C* classes are all thrown into one, and these are arranged in order of age instead of any kind of intellectual order, furnish a fairly satisfactory answer to this inquiry. What, of course, in full strictness we ought to do, is to get hold of the same men and measure them each year from 18 to 24, say, and then, by comparison of a number of such sets of observations, decide if there is any growth in the dimensions. This we could not do, for the men who appeared were all volunteers who could not be summoned for re-measurement, and indeed very few of them could have been found who would be resident for a sufficiently long period. But one of the many conveniences of the statistical handling of large numbers is that, for certain purposes, the examination of different men at the same time will be practically equivalent to the examination of the same men at different times. So here. Take 400 or 500 different men at each successive age from 18 to 24, and the results for statistical purposes will be just the same as if we took the same batch of men and measured them year after year. We feel confident in doing this, because we know that the

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\* The figures given in the table were obtained as follows: Three measurements of the head of each man were taken: the width, from side to side; the depth, from front to back; and the height, above a plane passing through the ears and eye-balls. These three multiplied together, yield what we may call a "head-volume," viz., a number proportional, on an average, to the size of the head. What in strictness we ought to have taken for subsequent examination would then be the *mean of these products*. But, as this would have taken very great labor, I have taken instead the *product of the means* of each of the three separate measurements. The difference thus involved is very small, and for the purposes of our inquiry is quite unimportant. The average of these products is about 240; the "probable error" of the individual products is about 17. The usual formula for the "probable error" between the means of two batches, each containing 1000, would be  $17 \times \sqrt{1 \div 500}$ , viz. less than 1. The actual difference amounts to 7, which is enormously improbable as a chance result.

men who come up year after year all belong to the same homogeneous class.

AGE . . . .	18	19	20	21	22	23	24	25
HEAD . . .	236.4	236.7	237.6	238.3	239.8	240.6	243.5	243.5

These represent a total of 3192 men. The last compartment comprises those of all ages from 25 upwards, though those who are beyond this last age are extremely few in number. The figures indicate a slow but unmistakable growth in the size of the head during the whole of the college career. It may be remarked that there is no growth of stature perceptible during this period.

There is one very important conclusion which may be drawn from the results of these anthropometrical observations. It concerns what—if this is not too pedantical an expression to use—may be called the theory of examination. In England, and elsewhere, a large number of posts in the Civil Service and other branches of the state employment are awarded by the results of examination. There is, of course, in most or all of these some preliminary physical test demanded; but this is merely a requirement which every candidate must pass; it forms no part of the real examination itself. No marks are awarded for distinction in this respect, and no further attention is paid to it in case the candidate succeeds in satisfying the medical man that the minimum requirement has been attained.

It has been suggested, however, that something far beyond this might conveniently be introduced. As the grounds on which such a suggestion is based are not generally understood, a few words of explanation may be advisable. In most of the examinations of any magnitude with which the state is concerned, it may be taken as a fact of experience that the number of candidates bears some moderate ratio to the number of those who compete. If, for instance, there are 30 posts to be given away, we should expect perhaps 60 or 100 to apply for them: it would be a rare thing to find these numbers as low on the one hand as, say, 35, or as high on the other as 300 or 400. From this an important consequence follows. It is well known that whenever a considerable number of objects are arranged in order of magnitude or intensity in respect of any quality, the differences between them are very much greater towards the two

ends than towards the middle. This is only a case of the so-called Law of Large Numbers. If it was a case of measurement of stature, for instance, of one thousand men, we shall probably find that at the top and bottom of our list,—amongst the giants and the dwarfs,—two successive men might differ by as much as several entire inches; whilst towards the middle we might range over one hundred without finding a total difference of a single inch. The same fact is notoriously true in examinations, wherever marks can be assigned with any accuracy. In mathematics, for example, the first few men will differ widely from each other in merit; and, if the same does not hold good of the men who come last, this is partly because the really bottom men know better than to go in for such an examination. They have been otherwise provided for.

It follows from these two facts,—the law of grouping about the mean, and the empirical observation as to the proportional numbers of candidates,—that the men who are only just excluded are practically quite as worthy as those who are only just admitted. Accident rather than merit has determined their fate, the differences amongst them being too small for accurate determination. Suppose, to put a fictitious case, that three hundred men had applied for one hundred posts in the army or in the civil service. The examiners do their work, and give us a list of the one hundred who come out first. But if they have any experience they are well aware that if they were to go through the same process a second time, or the task were assigned to another set of equally competent examiners, the result would be different. All the men who were high up in the list would invariably be again secured, but it is not at all unlikely that some ten or fifteen of those at the bottom would find that their places had been taken by others.

We know, then, that in respect of the subject-matter of that examination it really matters very little which particular set of men we select, provided that we are speaking of those who are some considerable way down the list. We adhere to the examiners' order, not because we have any firm faith in its accuracy, but because there would otherwise be suspicion of unfairness. But it becomes a pertinent inquiry whether some other test, of a physical kind, might

not be introduced in order to distinguish between them. In the above example ; if we take the ten who just get in and the twenty who just fail, we know that they are all, so far as the intellectual character under examination is concerned, practically on a par. But, so far as their physical character is concerned they are by no means on a par, but will differ as widely as any random selection of thirty might be expected to do. We might therefore gain much as regards the body, and lose very little as regards the mind, by subjecting these thirty to a purely physical test, and selecting the ten best, on this ground alone. So long as it was doubtful whether bodily and mental excellence were not to some extent antagonistic, there might have been considerable risk in adopting such a course. But now that we know that there is decided evidence in support of the view that these qualities are independent of each other, it is otherwise. Amongst the thirty men between whom no ordinary examiner could rationally and confidently discriminate, the physical examiner will probably find a very wide difference.

If it ever were found desirable thus to introduce physical tests into our examination procedure, the physiologist and medical man would have to be consulted as to the particular form of test to be selected. So far as our special results are concerned, I should have been inclined to think that the best single test is that of the breathing power. The general law that excellence in one department is correlated with decided superiority in all others seems to be more than usually applicable here. Experience shows that our physical first class, when selected on this ground, yields a slightly higher level all round than when selected on any other ground, though the difference is not great. I was also inclined to think, at first, that there might be a further advantage in the fact that this characteristic was, so to say, somewhat more deeply seated in our frame ; that it might not, therefore, be so readily "crammed" for the special purpose of examination. But an expert in such matters informs me that this is not so, and that an ingenious "coach" can, with a little training, soon produce a large relative increase in the measured capacity of inspiration and expiration. The fact is, unfortunately, that whenever we resort to examination of any kind we shall sooner

or later find that we have to reckon with the crammer. His ways are past finding out, at any rate by devices to which the examiner can fairly resort. Many a little scheme, which in itself would have been excellent as a test, has been ruined in this way. Could the men have been brought forward in uniform ignorance of what they were going to be subjected to, we might have secured an excellent means of discrimination amongst them. But the crammer's foresight has anticipated us; and we soon find that what we are really testing is, not the natural capacity of the men, nor even their acquired capacity, but rather the ingenuity of their temporary teacher and the length of time they have been under his charge.

Whilst on this subject, there is one illustration of too important a nature to be omitted. It has been already pointed out that, so long as we deal with any large homogeneous class, we may safely assume the independence of the physical and mental qualities. We feel sure that by raising our demands in the latter respect we shall not be obliged to lower them in the former. But when the class is not homogeneous this postulate is no longer sound, and we may fall into very serious error. Broadly speaking, the Cambridge students, as already remarked, are a very homogeneous body. But there is found amongst them, at the present day, a sub-class of a very different origin. The Indian students, though not a numerous body, have furnished a sufficient number of data for us to be able to draw some conclusions as to their general average characteristics. These men, it need hardly be said, do not come from the fighting races of the Northwest of the British Indian Empire, but almost exclusively consist of highly educated Bengalees. Intellectually they show no deficiency. They are, in fact, the sort of men who rise to the top in any examinations in which they are pitted against other natives. Some of them have already, by their success in the Indian Civil Service Examination, earned posts in which they assist in governing the British Empire. So long as their numbers are relatively small, probably nothing but good comes of this; but we may fairly ask what would come to pass if, in course of time, whether owing to their real capacity, their disposition to the career,

or their relative population, the number of selected candidates of these nationalities were to become preponderant.

Those who regard consistent adherence to the course in which we have once started as a prime duty, will doubtless say that this is all as it should be; for that the men who rise to the top of the list have thereby proved their fitness for the work to which that examination was the portal. I am not going to argue this question, but will just offer one small contribution to its solution. These clever Asiatics, who, as we find, can often hold their own against their European competitors in the examination-room, how do they compare with them physically? Reverting to our scheme of arranging the men into ten successive physical classes, what we find is briefly this: The Indian students, on an average, stand in respect of their "pull" in the eighth class; in their "squeeze" and height, in the ninth; in their breathing power, in the tenth. They are nearly half a stone less in weight, and their eye-sight is similarly below the average. Those who admit that physical vigor has something to do with the foundation and retention of empires will allow that such facts as these may some day stand in need of careful revision and discussion.

J. VENN.